DUNN

Reclamation of Land by Levying

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RECLAMATION OF LAND

BY

LEVYING

BY

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THESIS

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

JOEL ERNEST DUNN

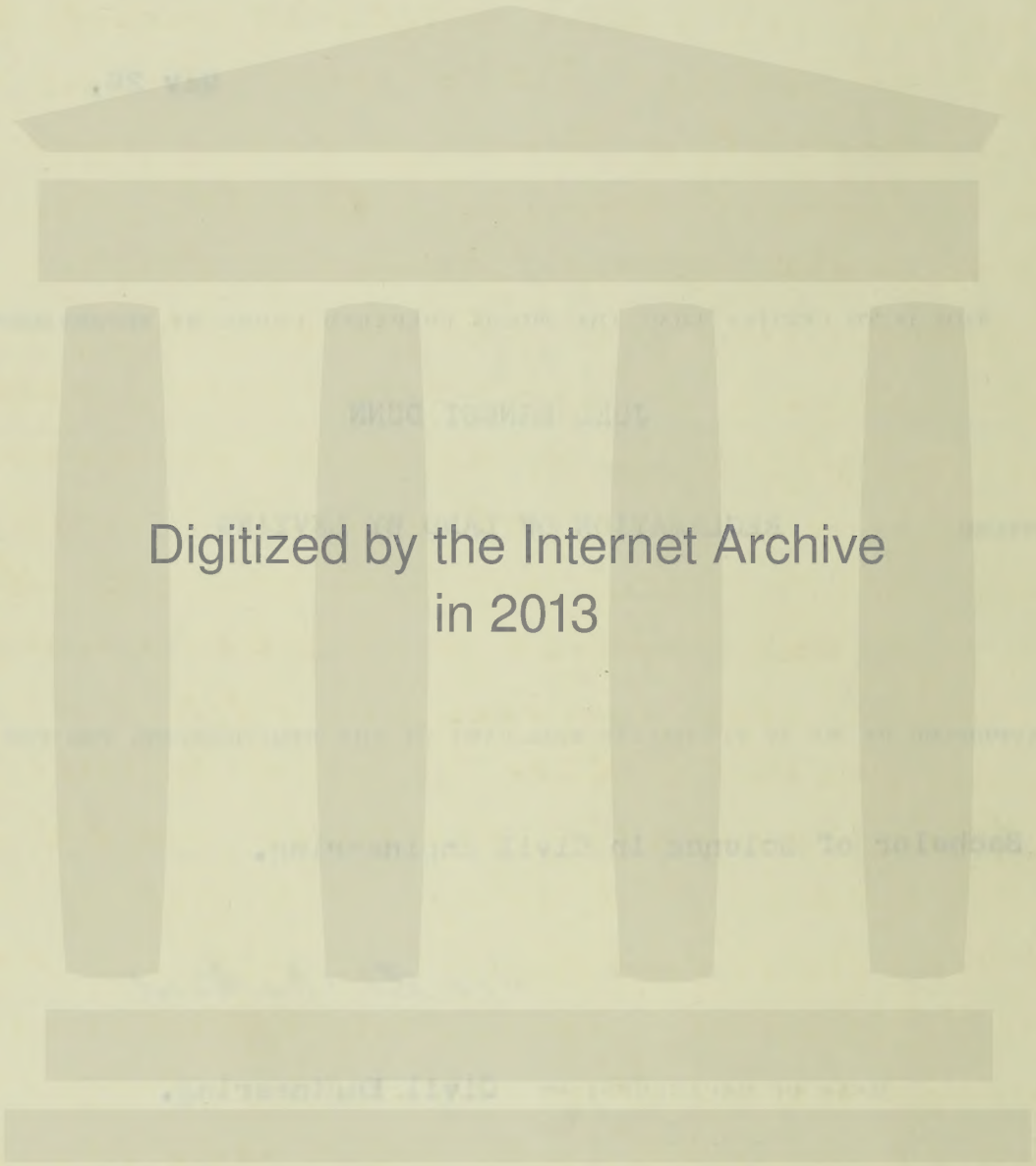
ENTITLED RECLAMATION OF LAND BY LEVYING

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Civil Engineering.

Ira O. Baker.

HEAD OF DEPARTMENT OF Civil Engineering.



Introductory and General Description

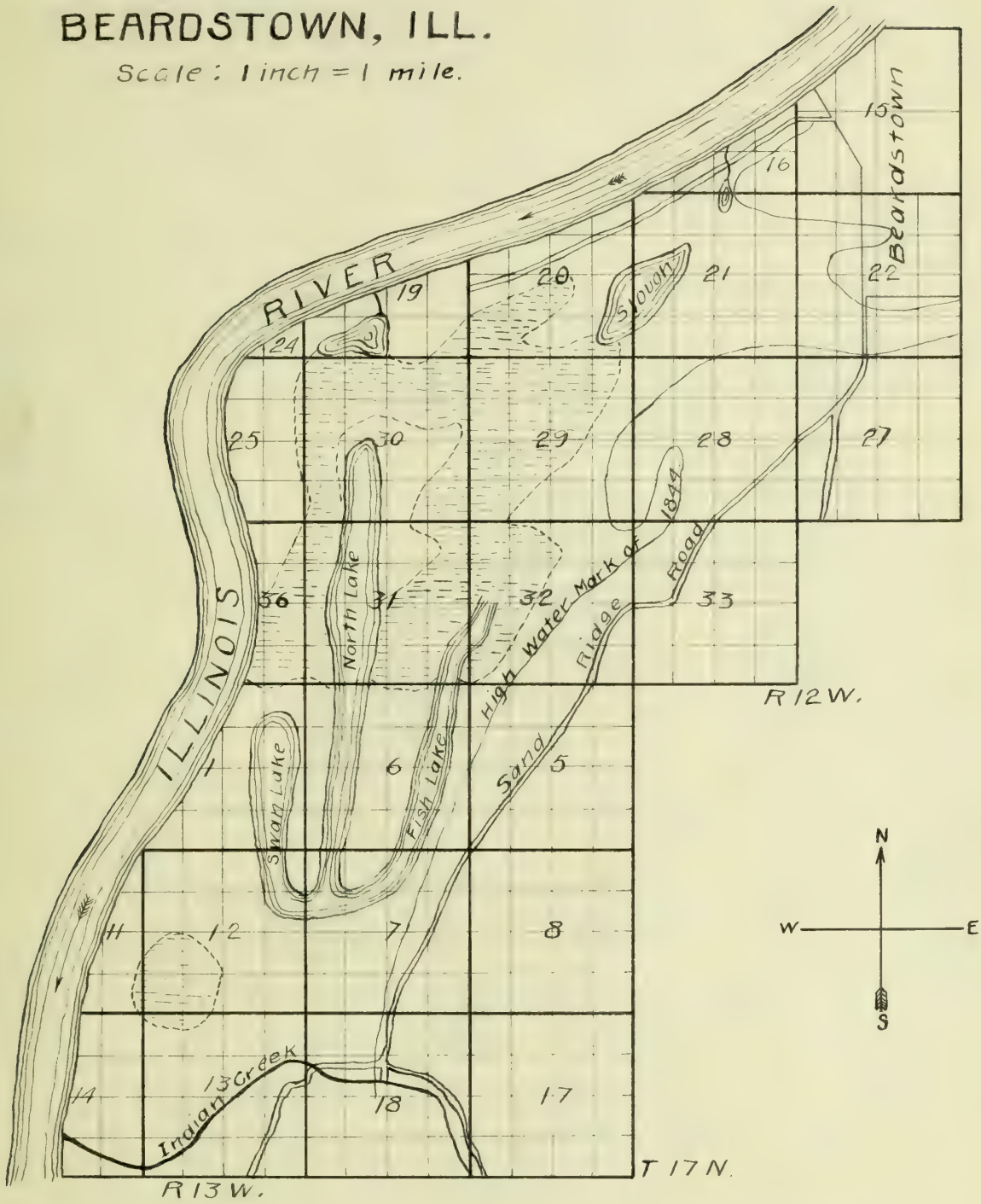
It is the purpose of this discussion to call the attention of those who are seeking profitable investments in land or in land improvement, to a tract of about 7,000 acres lying in the alluvial bottoms of the Illinois River near Beardstown, Cass Co., Ill. In view of the wide-spread fame of Central Illinois land for its fertility, for its high degree of improvement, and for the high prices which it commands in the market, it is surprising to find that there are any considerable areas of the richest of it still remaining unused and unimproved; yet the tract under consideration lies only 20 miles from the 40th parallel of latitude which is the central axis of a strip of some of the richest agricultural land in the world; a strip averaging approximately 100 miles in width and extending clear across Illinois into Indiana on the one side and into Iowa on the other. This strip contains the great "Corn-belt" of Illinois. Corn is the principal product; but oats, wheat, grasses, live-stock, fruits, etc., etc., are also grown

in great abundance and as successfully as corn. The land of the corn-belt has been farmed for over fifty years, and there has never yet been a failure of crops. Its price has been steadily rising ever since its settlement until at the present time all but a few comparatively small tracts, such as the one here considered, sells at from $100 to $175 per acre.

If properly protected from flooding by the river, there is no reason why this alluvial bottom, near Beardstown should not be equally as productive and valuable as the surrounding country. Indeed the practicability of protection has already been amply proven, since an exactly similar tract of land lying directly across the river from it, has been leveed for a number of years, and has produced immense profits to its owners. A description of this successful piece of land-redemption work will follow later on.

MAP
OF
ILLINOIS RIVER BOTTOMS
NEAR
BEARDSTOWN, ILL.

Scale: 1 inch = 1 mile.



Location with Respect to Market

When the Beardstown bottom is redeemed for cultivation, as it is bound to be in course of time, there will be no lack of a ready and convenient market for its products. There will be no waiting for the building of railroads, or of wagon roads, or of towns, as is often the case in newly settled regions. The land lies south west of Beardstown and immediately adjoining it. Beardstown is a city having a population of about 7,000, and is located on the east bank of the Illinois River twenty-five miles west and somewhat north of Springfield, the capitol of the state. It has direct railway connections with Chicago over the C, B. & Q. railroad, and with Springfield over the B. & O. S.-W. It is also an important shipping point for the traffic on the Illinois River, which gives it a direct connection with the markets of St. Louis, Mo. The U. S. Government maintains a navy-yard at Beardstown for the benefit of the boats engaged in the government work of improvement of the river.

No part of the land which it is proposed to redeem is more than five miles from Beardstown; and it would be possible to have a boat landing which would materially shorten the haul by wagons when river shipments were to be made.

Description of Tract.

The land lies in a strip averaging nearly two miles in width and about five miles long parallel to the river, which here flows in a general south-westerly direction. At the north this bottom is terminated by the high ground on which Beardstown stands. On the east is a long narrow ridge which extends from Beardstown to the south west, nearly parallel with the river, for the full length of the tract. This high ground on the north and east is entirely above all high water, thus giving natural protection on those sides. This ridge makes the engineering problem of protecting the land a comparatively simple matter. Across the south end of the

tract flows a small stream, called Indian Creek. This creek carries to the river the water from the country lying east of the ridge. To the west of the tract is the river, with between seven and eight miles of low bank which will have to be rendered safe from overflow by an artificial barrier.

The surface of the land enclosed in the above boundaries is very flat, the larger portion of it not being more than six or eight feet above the banks of the river. About 500 acres are covered by three lakes or ponds which vary in depth from 10 to 20 feet; and about 1,700 acres are marsh, being covered with water most of the year. The greater part of the area is now subject to overflow about once in four or five years. Not more than 2,000 acres are under cultivation at the present time, and much of this is only cultivated in seasonable years.

As to the fertility of the soil little need be said. Alluvial land is proverbially the richest to be found the world over. The overflows from the river are the cause of its practically inexhaustible fertility, and at the same

time the cause of its lack of utilization. With the high water from the river once effectually dammed back by levees and the water now standing on it removed, four fifths of the land would immediately be ready for cultivation. There would be practically no clearing to be done on most of it; no stones or stumps to obstruct the use of the most modern farm machinery. The plow could be put into the ground at once, and there would be no further delay to agricultural operations.

Engineering Features.

Considered from the engineering standpoint, the redemption of the whole land is a comparatively simple matter. The only directions from which an overflow can come are the west and south when the river gets out of its banks. It will be necessary to protect the west side with a levee about seven miles long and fifteen or sixteen feet high. As has already been stated,

the higher ground on which Beardstown stands and the "Sand Ridge" on the east side, the tract give perfect natural protection from all overflows which might come from those directions. The ridge is without breaks or water-courses through it from Beardstown to the extreme south end of the tract, thus forming a perfect barrier to the waters which drain from the territory to the east. This simplifies the problem, as it entirely removes the necessity of disposing of any rainfall except that which comes directly on the enclosed area. At the south end there is a break in the ridge and the small stream, Indian Creek makes its way through it to the river, draining the country east of the ridge. It will be necessary to construct a levee about two miles long across the south end to prevent flooding of the tract by high water in Indian Creek. To remove the standing water and the rainfall, it will be necessary to have a system of channels leading to a pumping plant. The construction of these channels is much facilitated by the

fact that good, deep natural channels already exist, so that perhaps 50 per cent of the excavating which would otherwise be necessary will be saved.

Success of Similar Undertaking

That the plan as proposed above is entirely feasible and highly profitable has been amply proven by the success of a very similar enterprise on the west side of the river directly across from the tract under consideration which has been in operation for a number of years. The land on the west side, before reclamation, was exactly similar in character to that on the east side. Like the land on the east side, it is low and flat and lies at about the same elevation above the bed of the river. Also, in its natural condition it was covered largely by marsh and ponds, and was subject to overflow at the same time that the east side was. The greater part of the area was not tillable at all; the rest of it being in cultivation only in favorable years.

at the present time the whole tract is under cultivation, with the exception of some ponds which are purposely left for the fish they contain. There is no richer or more productive agricultural land the state over.

History of Christy and Love Enterprise

In 1897-98 Christy and Love, contractors and investors, having at that time become owners of the bottoms comprising approximately 6,700 acres across the river from Beardstown, constructed the works necessary to render the tract safe from overflow and to remove the standing water. Attempts were made to buy up the entire territory so that the project could be put through as a private enterprise; but a few of the small land owners refused to sell at any price, and as a consequence it was necessary to organize a drainage and levee district under the laws of the State of Illinois and to prosecute the work as a public enterprise.

The plan of redemption, to state

it as simply as possible was to construct a levee along the river and wherever needed to dam back high water, and to remove the surface waters by means of a pumping plant. The topographical features were such that the engineering problems were considerably more difficult than is the case with the bottoms on the east side of the river. In the first place there were no natural channels to conduct the water to the pumping plant, and it was necessary, therefore, that all drainage should be obtained by artificial channels. Also there was no ridge separating the bottoms from the territory back of them, and the rainfall from this higher ground drained naturally into the tract it was proposed to redeem. One favorable picture was that the B. & O. Railroad had four miles of embankment along the banks of the river which would serve admirably as a levee; and further, the railroad company was perfectly willing to have its trestles filled up and to allow the levee to be joined to its embankment. This left about 7 miles of levee, 12 feet

to 16 feet high, to be constructed. It was decided that the cheapest method of constructing the levee would be by the use of a floating dipper dredge, especially as this type of dredge would be needed anyway to dig the required drainage ditches. Five miles of main ditch were needed and about 16 miles of laterals.

When the nature and amount of work to be done was finally determined, bids were received from contractors; but none were satisfactory, and Christy and Love undertook the construction themselves, with the result of a considerable saving. Ordinary excavation by means of dipper dredge where no care is taken in dumping the earth, costs from 8 to 12 cents per cubic yard; but owing to the fact that it was necessary to use an 85-foot boom on the dredge and to take particular care in dumping the bucket, the price on the levee was from 12 to 16 cents per cubic yard. The earth for the levee embankment was taken from a borrow pit between the embankment and the river. The dredge boat floated in the

water of the borrow pit, and dug the pit ahead of it parallel with the embankment in the usual way. The levee was designed to have a top 5 feet wide and 3 feet above the highest known water. The slope on the river side was to be 3 to 1, and on the other side 2 to 1. However, it was found that the dredged earth, being mixed with water, would not stand at such steep slopes, so the slopes were disregarded and the only effort was to get the earth piled up high enough. When the embankment had reached the required height, it was found at all places to be much wider, both at top and bottom, than had been considered necessary. No attempt was made to secure a smooth or neat looking embankment, though it was not so rough as the ordinary dumps of a drainage dredge ditch. In estimating the cost per cubic yard as stated, only the volume required by the specifications was considered, though much more, perhaps twice as much, was actually excavated

The larger ditches were excavated by the same machine after the levee

at a cost of from 10 cents to 12 cents per cubic yard.

It was foreseen from the first by the engineer in charge and by the principal owners, that it would become necessary to construct works to take care of the water coming from the higher ground; but, owing to the fact that among the small land owners there were some who were in a chronic state of opposition, it was thought to be more politic to say nothing about that and not to include it in the original estimates. After the completion of the rest of the work, and after the value of protection had been demonstrated, it was thought that the hill water could be disposed of without material opposition. Later events proved the wisdom of this course.

Cost of Redemption.

The original assessment was $106,000, which covered the cost of construction of all the engineering works, exclusive of the intercepting ditch to take the hill water, and

including 7 miles of levee, 5 miles of main ditch, 16 miles of lateral ditch, and a pumping plant with three centrifugal pumps throwing 35,000 gallons per minute. In round numbers the levee cost $75,000, the main ditch $10,000, the lateral ditches $5,000 and the pumping plant $10,000. The original cost was thus about $15 per acre.

As was foreseen, the hill water gave trouble and injured the first two crops after the completion of the rest of the work, but by that time the land had convinced the most skeptical that it was worth protecting and a clamor for an intercepting ditch was raised by the very men who would probably have opposed it the most strongly at first. A further tax assessment of $13,000 secured the ditch. Its construction was somewhat difficult owing to the fact that in some places the water had to be carried between embankments, the ditch bottom being 5 feet above the surface of the ground. The water is carried around the enclosed area and is emptied into the river to the south and outside of the levee.

Maintenance of Reclaimed Area.

In the crop season of 1899 most of the protected land was placed under cultivation, and produced an immense crop of corn, the yield running from 60 to 100 bushels per acre. There has been no diminution of returns since. The fish ponds produced revenue of several thousand dollars per year.

The cost of maintenance has been extremely low. In 1903 the Illinois River reached the highest stage since 1844, giving the levee as severe a test as there is any probability it will ever have to stand in the future. The levee was carefully watched, but at no time during the great flood were there any indications that it was in danger. The only injury done by high waves was at one point, and this was repaired by a half day's work with two teams. Aside from this half day's work the levee has cost absolutely nothing for repairs since its completion. For the first six years it was necessary to keep the pumping plant running for an average of nine days per year with

a maximum of about one hundred days. But during part of this time there was no intercepting ditch, thus making it necessary to pump the hill water in addition to the rainfall on the reclaimed area, and also causing a considerable loss of crops by torrential washing at the foot of the hills. This ditch required quite a considerable amount of repair and trouble, and the hill water was not successfully controlled for four or five years after the completion of the levee. With only the rainfall to dispose of it is probable that it will not be necessary to run the pumps more than sixty or seventy days per year. There has been no noticeable seepage through the levee.

The total average annual cost of maintenance, which includes pumping, engineer's salary, etc., has been 25 cents per acre.

Summary of Results.

It is impossible to give exact figures as to the profits realized from this venture, but it is easy to get at it approximately. The first thing to consider is the original cost of the land. The very best of it would hardly have brought $5 per acre in its unimproved state. Much more of it would have been dear at $1 per acre. However it was known that the land was being purchased for speculative purposes, and the owners accordingly held it for much higher prices than its actual value in its unimproved state. It is safe to say that the average price per acre was somewhere between $2.5 and $5; probably nearer $2.5 than $5. It is certain that $5 per acre is a larger price than was actually paid for any of it; but, nevertheless, using it as a basis we can make a rough determination of what the profits must have been, calculating them as small as possible. To the purchasing price add $1.6 per acre for levee, drainage, intercepting ditch, etc.; and the amount

invested could not possibly have been more than $66 per acre. Since the completion of the work of redemption, none of the land belonging to Christy and Lowe has been sold, and practically none belonging to the small owners. For this reason the price which it would bring in the market at the present time is a matter of conjecture; but land of similar productiveness and convenience for shipping sells readily everywhere in the corn-belt of Illinois at from $125 to $175 per acre. The price for which all such land rents varies from $5.00 to $7.50, cash, per acre per year, or from two fifths to one half of the grain. Basing our estimate on the impossibly high cost of $66 per acre as given above and taking the present value at $135 per acre, it will be seen that the land has approximately doubled in value and has been producing an income of 9 or 10 per cent of the original investment besides. The greater part of the rise in the value of the land came between the times of beginning the redemption work and harvesting the first crop, but there has also

been a more gradual rise since then, owing partly to increasing confidence in the safety of the land and partly to the fact that all land in Illinois has been advancing in price. The above estimate is so conservative as to make the profits absurdly small. If there were any way of making an accurate determination, the return would in all probability be found to be one half larger or perhaps even twice as large as above.

East Bottoms an Equally Good Investment.

The preceding estimate has been given as a basis upon which to make a determination of the profits which would be likely to accrue from the redemption of the yet unimproved area on the east side of the river. With a knowledge of what has already been successfully accomplished we can reach a very close approximation as to the character and amount of the work needed in the proposed enterprise, and also as to the cost and remuneration. This is made possible by the

great similarity in the natural conditions of the two tracts. The southern half of the one is directly opposite the northern half of the other, and they are in plain sight of each other, so there can be no difference in rainfall or other climatic conditions. They both have the same kind of alluvial soil, deposited by the same stream under the same conditions so there could be very little difference in the fertility on the two sides of the river. There is no noticeable difference in the elevation of the land west the river and back from the bank, the general character of the surface is the same, though the unimproved tract has a few more deep ponds and also some natural channels for water which were entirely lacking in the other. The levee on the east bank would have to be of practically the same height as that already existing on the west bank and could be constructed in the same way. The eastern tract would need approximately the same amount of levee along the river, 7 miles, as the western tract; but there would need to be one and a half or two miles of somewhat lower levee along Indian

Creek in addition. The marshes have a natural drainage into the three connected lakes, - Swan Lake, North Lake and Fish Lake - and it is only necessary to lower the water in them sufficiently to leave the greater part of the marshy land dry. The lakes will need no deepening, except perhaps in a few places, as they are already from 10 to 20 feet deep. It will probably be necessary to do some dredging for drainage purposes; but not more than one or two miles of this sort of ditch will be needed. The amount of smaller lateral ditch and of tiling could be determined only by a detailed survey of the surface and a study of the porosity of the soil. For a rough determination we can again use the experience gained across the river. There the amount of open lateral ditch required was 16 miles making it improbable that the tract of almost equal area on the east side would require more, especially as the natural drainage is better. As has already been explained, nature has given perfect protection from the water of the territory back

of the sections. This consideration of the general features of the problem would indicate that the amount of levee required per acre is considerably greater than is the case with the land already redeemed, but this is partly offset by the fact that the cost of drainage is much less.

Considerations Affecting Cost of Land.

At the present time the land is almost entirely in the hands of small land owners who put about one third of it in cultivation every year, though they do not always get a crop. In addition several hundred acres are sometimes cultivated and sometimes not, depending on the river indications. Corn, wheat, oats and melons are raised now. The population consists of about a dozen families. The writer is informed by an inhabitant of the tract that under present conditions the very best of it is worth not more than $40 per acre, while much of the marshy part could be bought for $1 or $2 per acre. Of

course, if it were being bought up for speculative purposes these prices would be likely to rise from ten to one hundred percent, and probably some of it would not be for sale at any price. Taking all things into consideration the land of practically the whole tract should be obtained for an average price of not more than $30 per acre at the most; but to be sure beyond all shadow of a doubt, we shall use a price of $40 in estimating the cost of carrying out the enterprise.

If the investors in the reclamation enterprise should find themselves unable to acquire the ownership of the entire tract, it would be necessary to organize a levee and drainage district under the laws of the State of Illinois and then the work would be paid for by means of tax assessments on the land. It would be better if the investors could put the work through as a private enterprise; but the organization of a drainage district could be accomplished without trouble, as the only owners who would refuse to sell at a good price

would be those who expected the scheme to be a success, and were intending to reap the benefits. The practicability of redemption has been so well proven that there would be very little opposition due to prejudice, ignorance, or "bull-headedness". The cost in money of organizing the district would be negligible in such a rough estimate as this. The time lost would probably be a somewhat more important matter, but past experience under similar circumstances indicates that this feature is not at all serious. The price of $40 per acre will easily cover the cost of the land and of all necessary expenses up to the time when the work of construction is to begin.

Construction and Cost of Levee.

The exact location, length and volume of the levee will necessarily have to be determined by a careful survey of the ground and by a knowledge of the height to which the water will rise at [illegible] of the river

currents which the levee is to withstand when the water is high. However the Illinois River has so little current at this place that this last feature cuts very little figure either at high or low water. The closeness with which the embankment follows the curves of the river will materially affect the linear distance to be covered, but the ground is so flat that the height will be practically the same if located anywhere near the banks. The length of the levee along the river will be approximately 7 miles. It will not be over 16 feet high at any place; and at the northern end as the ground gets higher the levee will be much lower. Estimating roughly, the average height will be between 12 and 14 feet. Taking the height of levee as 15 feet the length as 7 miles, and using the section which has stood the test so successfully on the other side of the river, - 5 feet wide on top with slopes of 3 to 1 and 2 to 1 on the outside and inside respectively - the volume of the river levee will be about 873,000 cubic yards. The same slopes and top width would be advisable

on the 2 miles of levee along Indian Creek. The height of this levee will be, on an average, about 8 or 10 feet, say 10 feet, giving an additional volume of 117,000 cubic yards. This gives a total of 990,000 cubic yards of levee. It will be seen that in making the above estimate the height of the embankment is taken as being almost at its maximum for the full length of the levee, which of course gives values much too high. An estimate based on a careful survey would probably reduce this volume of earth by about 30 percent.

As to the method of constructing an embankment of these dimensions there is no doubt that the best and cheapest way in a place like this where there is water to float the machine, is by means of a dipper dredge boat, or floating steam-shovel, such as is used in digging drainage ditches. A boat of this sort floats in the ditch and excavates ahead of it, piling the earth in an embankment on the side. Where the only object is to excavate a ditch and no care is taken in piling the dirt, the cost is

from 8 to 12 cents per cubic yard; but the additional trouble of dumping carefully and putting the dirt all on one side and of piling it up to a considerable height increases the cost to between 12 and 16 cents. Using 15 cents as a price, which is certainly more than enough in soil of this character free from stones and troublesome stumps, and using the volume of 990,000 cubic yards obtained above, we find the total cost of the levee to be $148 500 or about $21 per acre of land protected by it. In order to get an idea of how much too large this estimate is, we can compare with the cost of the levee on the other bank of the river. This levee is 7 miles long and of approximately the same height and cross-section as the 7 miles which we are projecting. Its cost was $75,000. Using the 873,000 cubic yards of earth-work estimated for the proposed levee along the river and taking its cost at 15 cents per cubic yard the total cost will be roughly $131,000. Since the actual cost of a work of almost exactly the same magnitude and under conditions as

similar as it is possible for them to be cost only $75,000 we can safely conclude that the price of $131,000, making allowance for difference in time, is at least 35 or 40 percent too high. Yet we shall use this price in estimating the profits of the scheme first as though there were no precedent by which to judge.

Amount of Water to be Pumped.

Ample provision having been made for protecting the land from overflow by the river, the next step is to determine the amount of water to be pumped and the rate at which it will have to be pumped in order to remove the rain which falls in the enclosed area. The ordinary rainfall in Central Illinois is about 40 inches per year, which gives a volume of 92,928,000 cubic feet or 696,960,000 gallons on each square mile. On the 7000 acres in the tract this would mean about 7,680,000,000 gallons each year.

However these figures give no basis

on which we can estimate the rate at which the water will have to be removed by pumps. A large part of it will be removed by evaporation and by dissipation into the air by the vegetation, — particularly by growing crops. Experience has shown that there will be months at a time in almost any year when the natural disposal of the water makes the use of artificial means unnecessary. At other times there are likely to be great rainstorms as much as 10 inches of rain one fourth of the ordinary annual amount has been known to fall in this region in the course of 48 hours. If such a rainfall should come at a time when the surface of the ground were frozen or when the earth were already completely water-soaked, all the water falling would necessarily have to run down into the lakes and ditches which will furnish the main channels for conducting it to the pumps. In the course of three or four hours after the complete water-logging of the ground the water from the most remote parts of the area would be coming into the main

channels, so that the inrush would be at very nearly the same rate as that at which the rain was falling over the whole area. At the rate of 10 inches in 48 hours, calculating the fall as being evenly distributed, the inrush into the main channels would be about 600,000 gallons per minute. It would be impracticable to erect a pumping plant which would remove the water fast enough to keep the lakes and ditches from rising if it were coming in at such a rate. But 10-inch falls of rain only occur once or twice in the course of several years, and even then are not likely to come at a time when the ground is frozen or water soaked. At a time when the ground is frozen there would be no crops to be injured by flooding. Also the main channels should be kept pumped down low enough so that a rise of several feet would not submerge the cultivated fields. Then, too, if the level of the water in the main channels is kept low and the ground is properly drained by tile, it will not be so completely water soaked as to produce conditions of flood like

the foregoing. So the likelihood, with proper precautions, that any disastrous results would follow such a rainfall is very remote indeed. Besides it would be equall disasterous anywhere in Illinois and it is not to be expected that these redeemed bottoms should be made safer than the best corn lands in the state.

The surface of the lakes and ditches will be about one fifteenth of the whole area. Therefore if 10 inches of rain were to fall over the whole area and all the water were to be accumulated in the lakes and ditches there would be a rise of the surface of the water of 15 times 10 inches or 150 inches. If only half of it should be gathered into the channels there would be a rise of 75 inches or 6 feet and 3 inches. In soil of this nature a rise of the surface in the channels would be accompanied by a rise of the surface of the water contained in the ground and the rainfall which would go to cause this rise in the surface of saturation in the ground would certainly be much more than that which would

contribute to the rise in the channels. There is not much data by which to judge as to the proportional parts of the water which would be temporarily held by the ground and which would enter the channels as flood water, but observations on streams through flat cultivated areas indicate that not more than 35 percent of the water falling in great rainstorms is carried off by the streams as flood water. The rest is held by the ground, evaporated, or fed into the stream later as ordinary or dry weather flow. There is no reason why a greater percentage than this should reach the main channels of the tract under consideration. During the rainfall this would produce a rise of about four and a half feet. This rise would later be increased by the slower percolation from the ground if not kept lowered by the pumps.

From this it would seem that the plan to pursue would be at all times, or at least at all seasons of the year when excessive rainfalls are likely to occur, to keep the level of the water in the lakes and ditches

pumped five or six feet below the point at which they would be likely to overflow or injure the cultivated land. The pumps should have a capacity which would be able to remove the ordinary run-off of the land in the rainy times of the year and in addition be able to lower the surface of the water in the main channels a distance of four or five feet in a reasonable time, say in 5 days. The determination of this required capacity is impossible in anything but the roughest way, owing to the lack of data on which to base calculations. What data there is indicates that from December to May there is about the same amount of rainfall as there is from June to November, but in the latter season direct evaporation and dissipation of water by growing crops is so great that stream flow is little affected. Statistics for the Des Plaines River near Chicago show that from December to May the stream flow is about 38 percent of the rainfall for the same length of time. As the area drained by the Des Plaines is very similar in

character of surface, climate, and amount of rainfall to the tract near Beardstown, we will assume that these statistics will apply there also.

The rainfall for the six months from December to May is about 3,840,000,000 gallons and a 40 percent run-off to the main channels would give 1,536,000,000 gallons to be removed in the six months. Taking this run-off as being uniform for the six months, the amount to be pumped each day would be about 8,533,000 gallons or at the rate of about 6000 gallons per minute. To lower the water 5 feet in 5 days over an area of 500 acres, which is about the surface area of the lakes and ditches would require the pumping of approximately 21,792,000 gallons each day or at the rate of a little over 15,000 gallons per minute running 24 hours per day. These figures would indicate that pumps with a capacity of 21,000 gallons per minute should be able to take care of the ordinary run-off and with the help of the lakes as storage reservoirs to prevent flooding by excessive rainfall. However,

this estimate is based on such uncertain data that for the sake of perfect safety the pumps should be designed to have a capacity of 3,500 cubic feet, or 26,250 gallons, per minute. This agrees very well with previous experience. Across the river a capacity of 35,000 gallons per minute has been empld for the removal of the rainfall from approximately the same area, without the help of any storage and with the hill water to dispose of in addition. Since the construction of the intercepting ditch to keep the hill water from coming into the redeemed bottoms, the time during which it is necessary to run the pumps has been reduced by about one third. Since the pumps are run at their full capacity when they are run at all, it follows that the total amount of water to be pumped must have been reduced by about one third also, which makes the amount per acre to be pumped somewhat less than we have provided for in the estimate for the proposed plant.

The cost of the pumping plant across the river was only $10,000 or approximately $1.50 per acre. On this

rough estimate, where we are unable to tell certainly within fifteen or twenty dollars per acre what the original cost of the land will be, a difference of $1000 or $1 per acre on the price of a pumping plant will have very little significance. However it is advisable to understand something of what will be required and of the conditions to be met.

As the water will contain much sediment the type of pump to use will be the cent. frugal pump. The location of the plant will have to be determined by the engineer in charge of the work after a thorough survey of the ground, but, judging by the map, the place which would require the least amount of ditching to conduct the water to it is some point near the northern end of Swan Lake. The height to which the water will have to be raised can only be determined on after deciding on the level to which the water in the distributing ditches should be lowered and this, in turn, can only be determined by the depth which will be required to give a good outlet to

the lateral ditches and by the height to which the water will have to rise in times of extreme rainfall in order to come out over the surface of the fields. But the levee will be 16 feet high, which is 3 feet above high water, and as it is not at all necessary to run the discharge pipes over the top of the levee, placing the end of the suction pipe 7 feet below the foot of the levee will give a lift of 20 feet, which should be ample.

To raise 3,500 cubic feet of water 20 feet in 1 minute would require the expenditure of 133 horse power in useful work. This neglects the added 3 or 4 inches due to the friction in the pipes. But the efficiency of centrifugal pumps varies from 50 to 80 percent so that the work done in lifting the water would only be from 50 to 80 percent - say 70 percent - of the power delivered to the pumps. This would require the delivery of 190 horse power to the pulley or other driving gear of the pumps. In order to save part of the lift the outer end of the

discharge pipe should be brought down so as to discharge below the surface of the river in order to secure the effect of a siphon. This would require careful fitting and calking of pipes to secure air-tightness. By this means the head to be pumped against would be only the friction in the pipes and the difference in level between the surfaces of the water inside and that outside the levee. At times of extreme high water this difference would be from 16 to 20 feet perhaps, as estimated above. When the water outside is lower than that inside there would theoretically, be no use for the pump except to start the siphon. At Havana, Ill. on the Illinois River, at a similar pumping plant it was found that with a difference of 18 inches between the water levels outside and inside the levee, and with the highest part of the pipe forming the siphon 15 feet above the inside surface, the siphon would run three or four days with the pumps stopped after starting the flow. This shows that the

siphon action is a very material help and that the delivery to the pumps of 1:0 horse power would only be needed once or twice a year or even less often. Still the plant should be designed to meet such emergencies.

It would be in the province of the engineer in charge of the work to decide on the means by which this power should be supplied to the pumps. Either steam or electricity could be used. If steam were used the power house would have to be located on top of the levee or some other artificial elevation where it would be safe from high water in the very improbable event that the levee should break. The pumps would need to be down as close to the water as possible and hence a practical direct connection with the engine would be impossible. The pumps, or pump, would have to be placed in a concrete pit to keep it from being submerged and would be driven by a belt.

In deciding on the type of engine to use, it must be taken

into consideration that there will be months at a time when it will be standing idle, so that no type with delicate parts to rust out would be practical. Past experience has shown that the ordinary crank and fly-wheel type with the simplest steam valve possible is the best. In order to furnish 190 horse power to the pump the nominal horse power of the engine would probably have to be 250. At least two boilers, furnishing 250 horse power apiece, should be provided so that in case one should be out of commission for any reason the other could supply the steam necessary. Of course one could not supply steam to pump the water against the head which would obtain when the river was at its highest stage, but at ordinary times it would be ample.

The pumps should cost not more than $3,000, the engine $5,000 and the boilers $10,000 making $18,000 in all for machinery. As has been said, the pumping plant across the river cost, installed, $10,000 or $1.50 per acre.

The plant at Havana, previously mentioned, which successfully drained 5,000 acres of lowland under conditions almost precisely the same as those met at Beardstown, cost $14,000, installed. For a pumping plant of this kind, $21,000 or, roughly, $3 per acre should easily cover the cost.

Another scheme which might be successful would be the use of a submerged centrifugal mining pump. This is a rather recent invention. The electric motor is placed directly on the shaft of the pump and motor and all are submerged below the surface of the water. It is claimed by the manufacturers that it will last ten or twelve years before rusting out. The power could be brought out by wire from Beardstown, thus doing away with the necessity of erecting a power plant. No priming would be needed to start the pump and the only attention needed would be turning the current on or off to start or stop the pump. However this method has never been given a good test, and while it promises

to reduce original cost and running expenses one half or more, it is not the purpose in this discussion to design the works, but rather to make a rough determination of the profits to accrue from the reclamation of the land with all costs at their maximum.

Cost of Ditches.

The question of ditching is the most indeterminate part of the whole problem. There is no way of telling, without an extensive survey for the purpose, how much will be needed or what the dimensions will be. There will need to be three kinds of ditches, a dredge ditch for the main channel, smaller open ditches or laterals, and tile ditches. Judging by the map there should be less than 3 miles of the dredge ditch, but we have no way of determining how deep it would have to be or how great a volume of earth would be removed. Also, it might be necessary to dredge deeper channels through some parts of the lakes.

The amount of open laterals should probably be about the same as that in the reclaimed tract on the west side of the river, which is 16 miles, but here again there is no way of determining width and depth. Some of these smaller ditches could be excavated by scrapers, some by ditching machines, and some by the spade. The only way to find out how much tile is needed is by experiment. If the soil is very loose and porous, as it is on the prairies of Illinois, a string of tile will take the water from the ground for several hundred feet on each side of it, while in dense impervious soil tile will not work at all. Perhaps the best way to determine the cost of ditching is to make another comparison of the conditions with those across the river. The length of main ditch required there was 5 miles with a cost of $10,000. There are 16 miles of lateral ditch costing $5,000. This is cheaper than it would be possible to do it on the east side of the river, for the owners, Christy and Love, did the work themselves and thus

saved the contractor's profit. In the prairies the cost of draining land with tile and open ditch is, under ordinary circumstances, about $5 per acre. We shall use this price now though it should be understood that the tile will not all be put in right at the beginning, but later as circumstances show the need for it, so that $5 is high for first cost. This gives a total cost of $35,000 as against $15,000 on the west side of the river for the drainage of almost equal areas of land.

Summary of Cost

Having discussed more or less fully the various items which will enter into the cost of securing the ownership of the land and of redeeming it for agricultural purposes, we present here a summary of the results in tabular form.

Cost of Redemption

Item	Total Cost	Cost per A.
Title to Land	$280,000	$ 40
Levee	133,000	19
Pumping Plant	21,000	3
Ditches	35,000	5
	$469,000	$ 67

It may be well to repeat that in making these rough estimates the costs have been taken higher than there is any probability that they will be. The original cost of the land and the cost of the pumping plant are perhaps 50 percent too high. There is very little likelihood that any one of the items would reach the tabulated cost, but that all of them would do so is so extremely improbable that it is not worth considering. It may be noted that the difference between the estimated cost per acre of the reclaimed land on the west side of the river and the cost given above is only $1.00. This is merely a coincidence, as there was no effort made to make them come out alike. The estimated cost

redeeming the eastern tract is $11 per acre higher than the cost of redeeming the other, principally to the greater amount of levee; but the similarity of the results is due to the fact that the original cost of the land on the west side of the river was taken at $50 per acre instead of $40 as on the east side. The former price was based on nothing but the certain knowledge that $50 per acre was beyond all doubt much more than was actually paid, while the latter price, $40 was based partly on more recent information received from a farmer who is an inhabitant of the tract in question and who knows the prices at which the owners hold their land. While the cost of $67 per acre for securing the ownership of the land and for redeeming it will be used in estimating the profits, a cost of $45 or $50 per acre would be much more reasonable and likely.

Risk

As the construction of the reclamation works will require about two years, there will be danger of an overflow during the progress of the work. Indeed, parts of the land are overflowed almost every spring. However the only injury that would result would be a delay to the completion of the work and possibly a delay of one year in getting the first crop. The kind of dredge boat which would be used could not work in water so deep or so wide that it could not get its "spuds", or anchors, against solid ground. It would be likely to be swamped and sunk also, but this is nothing unusual for this kind of dredge and does little harm excepting to lose time. The levee would not be injured by a flood during construction. The current in the river at Edmiston is so small that it gives no trouble. Even when a completed levee breaks the whole structure, or even a great part of it, is not destroyed and the injury usually consists of a few holes washed through it. The estimated cost is so

liberal that nothing need be added to cover the risk.

Cost of Maintenance

The expenses incurred in maintaining the works after completion would include those of hiring the services of a civil engineer and of a pump man, of cleaning out ditches, of patrolling and watching the levee in time of high water, of making necessary repairs to pumping plant and levee, and of furnishing fuel for the boilers. The civil engineer and the pump man would not be needed for their whole time and it would be eight or ten years before the ditches would need cleaning out. The cost of coal consumed per year, if coal be used, would depend upon the efficiency of the boilers, the skill in firing, the amount of water to be pumped, and the head to pump against, - all of which it is impossible to predict. The following estimate will amply provide for all yearly running expenses.

Civil Engineer	$1000
Pump Man	800
Fuel	1000
Repairs and Miscellaneous Expenses	1200
Total	4000

This would be at the rate of $0.57 per acre. An addition to this of $0.43 per acre, making $1.00 per acre in all, would provide a fund for the replacing of the pumping plant when worn out. The cost of maintenance on the west side of the river has only been $0.25 per acre per year; but this does not provide for the replacement of the plant or for the future cleaning and deepening of the ditches. Even when counting these items in, $1.00 is much in excess of the actual cost per acre for maintenance.

Profits.

With the foregoing estimates of cost in mind we are now ready to estimate the profits. As has been stated before, all land of similar productiveness and convenience for shipping sells

readily everywhere in the corn-belt of Illinois at prices ranging from $125 to $175 per acre, and the rent which is paid for the use of it varies from $3.50 to $7.50, cash per acre or from two fifths to one half of the grain. The only thing which would prevent this tract from becoming immediately worth an average price of $140 or $150 per acre on the market would be lack of confidence in its safety. But the feasibility of protecting it by the means herein advocated has been so amply proven by the enterprise of Christy and Love that very little trouble should be experienced on that score, especially after two or three good crops are produced. Taking the excessive cost of $67 per acre as a basis, it is safe to say that within two or three years after beginning the work of redemption, the land will be doubled in its market value and will be producing an income of 9 or 10 percent on the capital invested besides. Subtracting the interest at 5 percent on the money invested and 1 percent for annual maintenance we have left a clear profit of 3 or 4 percent per year.

This is a very good investment in its self, but when we take it into account that the capital value of the land will double in two or three years in addition to this, it is indeed surprising that the opportunity is still open. And there is no doubt that the opportunity is even better than has been represented, for every effort has been made in all the foregoing calculations to reduce the profits to a minimum which is almost an absurdity. There is no reasonable doubt that the investment is at least 25 or 30 percent better than has been indicated.

With the demand for agricultural land as great as it is at present, this opportunity will not lie unimproved much longer. It will only be a few years until some of the land which could now be bought for $1 per acre will be producing 100 bushels of corn to the dollar's worth. The only question is: who will reap the benefits?

The End.